SECTION 89

SWITCHBOARDS

89.1 REFERENCES

(89A) Code of Federal Regulations - 46 CFR Sub-chapter J

(89B) Code of Federal Regulations - 46 CFR Sub-chapter H

(89C) AMERICAN BUREAU OF SHIPPING, Steel Vessels

89.2 INTRODUCTION

This Section covers the Contractor Design and Provide general requirements for the Ship's Service and Emergency Diesel Generator Switchboards and power distribution.

For WSF Fleet-wide Standardization purposes, End No. 1 of the Vessel shall always be considered the bow, and this designation shall delineate port and starboard, fore and aft wherever they are addressed in the Technical Specification.

89.3 GENERAL

This document describes the general mechanical, electrical, and control specification guidelines to be employed in the construction of power generation control systems and switchboards.

The design shall include Ship's Service Switchgear, Ship's Emergency Switchgear, power generation control system, Programmable Logic Controller (PLC) for load shedding and

alarm and monitoring system interface, instrumentation, protective relaying and power distribution scheme. The equipment shall be arranged and integrated as described in this Technical Specification.

The Ship's Service Switchboards shall provide for control, operation, and protection of the three (3) OFE Ship's Service Diesel Generators (SSDG), shore power service, and ship's distribution systems.

The Emergency Bus Switchboards shall provide for control, operation, and protection of the OFE Emergency Diesel Generator (EDG) and the Emergency distribution systems.

In the general design and arrangement of the switchboards, particular attention shall be given to the equipment overall dimensions to ensure an installation with adequate overhead clearances and deck space.

The equipment shall be designed for continuous operation at the maximum ambient temperature to which the equipment and/or any part is exposed. All parts and subassemblies that could require servicing, repair or replacement during the life of the equipment shall be front accessible.

The switchgear shall be constructed to meet the application and quality criteria governed by society classification rules and guidelines set forth, but not limited to, the following Authoritative Agencies:

1. References (89A), (89B), and (89C).
2. IMO Rules.
3. Institute of Electrical and Electronics Engineers, Standard IEEE-45.
4. Underwriters Laboratories, Standard UL-891 and UL Standard 508.
5. International Electro-technical Commission Standards (IEC) as noted.

All switchgear shall be designed to meet all specific switchgear requirements of the Technical Specification and shall be constructed to the appropriate UL Standards by an OSHA approved, nationally recognized testing laboratory (NRTL), certified manufacturer. Switchboards shall also comply with UL Standard 1558 (partial – cladding of breakers only, do not duct the bus-work). A UL field inspection and labeling of the equipment shall be provided. The abovementioned UL field inspection report shall be provided to the WSF Representative no later that five (5) days after the inspection.

Unless otherwise noted, each switchgear section shall be designed and constructed as free standing units with provisions to bolt to a common foundation, and where required "bay" with other equipment or Switchgear.

The switchgear shall provide all necessary controls, regulation, protective relaying, and load management required for the Ship's Service Diesel Generators (SSDG), Ship's Service Bus (SSB) Ties, Emergency Diesel Generator (EDG), Emergency Bus, and Shore Power systems. The Switchgear shall provide distribution to the Vessel's Emergency and Ship's Service equipment & loads.

The power plant shall be arranged for an International Standard A-B-C phase rotation coordinated to match typical shore power connection phase rotation.

The switchgear shall be configured as a three-phase, three-wire ungrounded system operating at 480 Vac, and 60 Hz providing service to both variable and constant loads.

All electrical components shall be suitable for voltage and frequency variations in the ship's power supply.

The components shall be able to sustain service through a voltage variation of plus 6-percent (+6%) to minus 10-percent (–10%) permanent variation and a plus or minus 20-percent (±20%) transient variation for duration of 1.5 seconds.

The components shall be suitable for frequency variations to sustain service with a plus or minus 5-percent (±5%) permanent variation in frequency, and plus or minus 10-percent (±10%) for 5 seconds for transient variations.

Front access for all components shall be required. The Main Ship's Service Switchboard shall have access from the rear, and shall be provided with flush, removable door panels for each section. Each removable (door) panel shall be hinged and provided with a door stop to secure and lock in the open position. Door panels shall be easily removed by one (1) person, and provided with recessed non-conductive hand grabs for easy removal. Emergency Ship's Service Switchboard shall have removable side panels for access to the rear of the unit. Panels shall be provided with recessed non-conductive hand grabs for easy removal.

All section front covers shall be hinged and provided with door "positioners" to permit easy access to the interior and branch circuit breaker load side terminals. Doors shall be able to open fully 90 degrees from the front of the switchboard. Each door shall be provided with a three-point latching mechanism. Doors with large or numerous cutouts shall be provided with strong-backs to prevent them from racking or flexing. Components mounted on the backs of doors shall be made safe from accidental contact by operating personnel when the doors are open.

Servicing from the rear shall be limited to torquing bus connections and making up ship's cable, circuit breaker stab connections, and shipping splits on installation. The enclosure shall be NEMA Type 2 meeting Underwriters Laboratories Standard 891 enclosure requirements. Sheet metal barriers, to meet the intent of UL Standard 1558, shall enclose the Shore Power and generator circuit breakers, however, ducted busing will not be required. The intent is to have each generator section autonomous from the rest of the gear.

The Switchgear shall be designed and constructed to an IP22 degree of protection.

The Switchgear framework is to be constructed of code gage steel, precision welded providing the primary mechanical load bearing structure for the Switchgear including all doors, panels, compartmental divider plates, cover plates, bracing, bussing and component devices. All closure plates shall be fabricated from code gauge steel and shall have formed edges.

The switchboard shall be fitted with a continuous drip-shield with a one (1) inch turned down edge in the front. Cable entry into the Ship's Service Switchboard shall be through MCTs. For entry of cables from the top, the Contractor shall utilize bolt-on MCTs, NELSON Hevi-Duty, RGM style (8×1 or 8×2), or equal, with TECHRON gaskets, in the drip shield located in the optimum location(s) above the bus-work for cable entry. The MCT end packing-special shall be of a type that requires bolting access from one (1) side only (the top or exterior side of the drip-shield). See Section 87 of this Technical Specification MCT requirements.

The switchgear shall provide mounting rails to anchor the cables entering the rear switchboard section. The cables shall mount in a recessed cable tray large enough to accommodate various Vessel cables of the low smoke, water-blocked type. The recess shall be arranged to provide anchor points to brace and secure the cables between the cable entries to the cable lugs as required. See Section 87 of the Technical Specification for cable type, installation and identification.

The switchgear section shall be supplied to the Contractor coordinated with the module construction of the Vessel. The switchgear shall be designed and constructed as freestanding units with provisions to:

- Bolt and anchor the Switchgear to a welded foundation.
- "Bay" the Switchgear shipping splits as required.

The manufacturer shall provide the switchgear mounted to a temporary shipping plinth (foundation) constructed to be used as a lifting base. The base should be designed as a load-bearing element with integral picking points to shackle cables and intended for use with an overhead crane. Additionally, the temporary base shall be constructed for moving the equipment with the use of a forklift.

The lifting base shall be used one (1) time to move the equipment into place on the Vessel at the Shipyard. The base shall be easy to remove once the equipment is located in place on the Vessel.

Shipping splits shall be packed and crated for weatherproofing the equipment and desiccant packs shall be installed inside the electrical equipment.

All draw-out circuit breakers shall be individually packed and crated for shipment to the shipyard along with the switchboard.

All crates shall be properly labeled to identify the equipment inside.

The switchgear sections each shall be mounted to a common plinth (foundation). The plinth shall provide a kinetic isolation pad/gasket between the cabinet and the plinth base. The cabinet shall be thru-bolted to the foundation base. Provide a distributed isolation material (DIM) by E-A-R SPECIALTY COMPOSITES, or equal, between the entire footprint of the foundation and the line-up. The isolation materials shall be designed to minimize the effect on the equipment when exposed to the environmental conditions listed in IEEE-45, Section 1.6. Calculations shall be submitted to demonstrate that the materials and methods selected are effective in meeting this requirement.

Each switchboard component shall meet or exceed the criteria listed in this Technical Specification and be capable of providing continuous operation and duty installed in an ambient temperature range between “0”C degrees and 45C degrees.

The switchgear shall be designed to meet fire protection and flame retardation as specified in IEC 92-101 and UL 94.

The switchgear and related components shall be designed, constructed, and installed to meet IEC 68-2-6 vibration and physical shock criteria and shall meet or exceed the environmental criteria as set forth in IEC 68-2-1, 2, 30, and 52.

All switchgear control compartment components shall provide electric shock protection/finger safe protection to meet or exceed IEC 60 529/DIN VDE 0470-1.

System bus and lug connections shall provide a dead-front cover and be clearly marked and labeled to designate voltage and shock hazard.

The switchgear sections shall be provided with an integral handrail mounted on the front of the cubicle(s). The handrail shall be insulated and vertically mounted to the cubicles with counter-sunk thru bolted formed metal brackets.

All major electrical components and wearing parts, including potential and current transformers, distribution bus bars, power switches and draw-out and plug-on base circuit breakers shall be supplied by the SQUARE D Company, or equal. In the design, the Contractor shall use the switchboard remote control elements included with the generator contractor provided control package.

Pilot devices and operators shall be logically arranged in groups and physically located respective to function. Pilot devices shall be of the illuminated type and provide active illumination when in operation. Pilot lamp and operator terminals mounted on the switchboard doors shall provide finger safe and back of hand safe protection from electrical shock. All indicator/pilot lights in the switchboards shall be provided with momentary "push-to-test" capability.

Each switchgear section shall provide stand-alone functionality. Each switchgear section shall be supplied by two (2) independent 24 Vdc power sources for the control system.

Primary interrupts shall be rejection style cartridges coordinated with the switchgears design. Secondary interrupts shall provide "blown fuse" indication.

All mechanical fasteners used in the switchboards construction shall be designed to reduce the amount of different tooling required to service the equipment.

Materials should be selected for marine application with consideration to reduce the degree of dissimilar metals that may come in contact with each other.

The switchgear shall be clearly labeled for internal and external mounted equipment. Label plates shall be of "BLACK" phenolic with "WHITE" core (lettering) unless described otherwise. Label plates shall be secured in aluminum mounting tracks that are independently screwed-on from the label plates. See labeling requirements in Section 24 of the Technical Specification.

Fluorescent lighting fixtures (one (1) per section) ALKCO T-2 fluorescent terminal strip with remote ballast and converter, or equal, and capable of operating on 120 Vac shall be installed on the underside of the dripshield to illuminate the working surfaces of the switchboard. These fixtures shall have a 1" × 1" "RED" phenolic with "WHITE" core "E" designator affixed to them to identify an emergency lighting circuit. Label shall also provide circuit number and wattage of the lamps.

Internal fluorescent lighting , ALKCO, or equal, (120) Vac shall be provided in each section. Door switches shall activate the internal lighting. Additionally, one (1) light fixture shall be added in the center generator section behind the back pan in way of the bus-work. This fixture shall have a two-pole switch. Power for lighting shall be from the ship's final emergency power.

A standard three-prong ("U" ground) duplex, 120 Vac receptacle (PHOENIX CONTACTS, DUO, DIN rail mounted), or equal, shall be provided inside each section except the Distribution Section to support maintenance and troubleshooting. Power for the receptacles shall be from the ship's final Emergency Power.

Each section shall be provided with a thermostatically controlled standstill heater to protect internal components during dead ship or shipyard periods. Heater connections shall be brought out to customer use terminals for connection to ship's cable.

The switchboard exteriors shall be prepared for powder coating as set forth in Section 14 of the Technical Specification. Finish shall be "METER GRAY" (ANSI No. 49) powder coat. To provide better visibility of the interior of the switchboard, the interior of the sections, including the backs of the doors shall be painted "WHITE", applied over a metal etching, phosphate pretreatment primer. The Contractor shall supply a minimum of six (6) aerosol spray cans of each color for touch up paint. Aerosol spray cans shall be turned over to the WSF Representative.

Where space is provided for the future installation of a circuit breaker, it shall be complete in all respects with the exception of the circuit breaker and lugs. All necessary circuit breaker studs and mounting hardware shall be provided. The front panel shall be cut out and fitted with a suitable cover plate.

The manufacturer's construction practices shall maintain proper distances between live parts, of different potentials, and structural metal components. Insulating materials are to be suitable for the working potentials of the Switchgear.

The switchgear shall provide copper bus bar rated and sized to accommodate up to 20-percent (≤20%) future expansion. The bus shall provide suitable connections for the line side feeders and all provisions for future expansion.

The bus connections shall be bolted to the SSB bus bar and held captive with BELLEVILLE, or equal, washer/nyloc nut-bolt combination. All connection points shall use an anti corrosion-inhibiting compound suitable for the installation.

The Switchgear sections shall provide a solid copper isolated grounding bus bar equal to the current carrying capacity of the main bus bar.

All connection stab bus-work will be permanently stamped "A", "B" & "C" respective to phase near the connection lugs.

Control, instrument and accessory wiring shall be No 14-12 AWG, SIS, multi-stranded switchboard wire. PLC wiring shall use No 18 AWG, SIS multi-stranded wire. Fuse blocks within the switchboard shall be furnished when required. All control and power wiring shall

be provided with floaters, this includes jumpers and spares. See Section 87 of the Technical Specification for additional requirements as to installation and construction.

Terminal blocks shall be PHOENIX CONTACTS Brand, or equal, single level. Avoid the use of multi-level terminal blocks. All terminal blocks shall use suitable numbering strips (keyed to Contractor drawings) using the PHOENIX CONTACT ZB custom printed labeling system. Terminal blocks shall be installed in way of the shipping splits directly at the splits. These blocks are to be dedicated to control wiring that transits the splits. The intent is to not run the inter-split wiring in bundles with other control cables. Cable bundles shall not be disrupted to break the sections.

There shall be no bare wire conductors' terminated to any device, component, or terminal strip. All conductors shall have an approved connector installed, ether a ferrule or a ring terminal. All terminate lugs or ferrules shall be installed using an approved controlled cycle crimping tool, of the same manufacture. See Section 87 of the Technical Specification for additional requirements as to installation and construction.

Each switchgear controller shall include terminal IEC style block systems.

Switchboard wiring to terminal blocks shall be provided with PHOENIX CONTACT ferrules. All relays, metering, controllers and accessory hardware used in the switchgear shall have a high tensile strength, anti-corrosive, cadmium plating on connection terminals. Ring terminals shall be used on instruments and screw-type connections. Control wiring shall be colored using "RED" for 480 Vac, "BLUE" for 120 Vac and "GRAY" for DC voltages. PLC wiring shall be "YELLOW". See Section 87 of the Technical Specification for additional requirements, as to installation and construction.

All switchboard wiring shall be neatly formed in groups and supported to the switchboard in such a manner as to avoid chafing due to vibration. Adhesive supports or cable retention devices **shall not** be used in the construction of the Switchgear. All power conductors shall be adequately braced using USCG approved materials to withstand the maximum possible fault currents. The use of adhesive-backed retention devices to support control or instrument wiring **will not** be permitted.

The switchboard manufacturer shall be responsible to ensure that the switchboard control and automation components, including integrated relays, integrated meters and PLC controllers shall be an integral family of control components. The manufacturer shall ensure that internal and local network connectivity is common to one family of process control equipment. Control and automation components used in the switchboard for power and generation control shall integrate seamlessly with the Alarm and Monitoring System (AMS) hardware and communication protocols.

It will be imperative for the switchboard manufacturer to work closely with the Ship's Service Diesel Generator Contractor to integrate all of the desired functions into the switchboard. The SSDG Contractor will be responsible for the final set-up of the EFI (Electronic Fuel Injection) controller equipment.

A 1" × ¼" full-length of the switchboard, silver or tin plated, copper ground bus shall be fitted for grounding the cases of instruments, relays, meters, instrument transformers and their secondary windings.

Potential Transformers (PT) shall be used for all circuits that are connected to potentials greater than 120 Vac and above, unless noted otherwise. PTs shall be fused to match VA on both legs of the primary side with fuse holders and fusing matched to the interrupt rating of the Switchgear. Primary fuse cartridges shall be of the 35 kAIC rejection type. PT secondary fusing will include fuse holders with "blown fuse" indication on the secondary side and fused on the ungrounded leg of the secondary side.

Potential Transformers (PT) and Current Transformers (CT) shall be used with all instruments, meters, and protective relays.

Current Transformers (CT) shall be provided with shorting terminal blocks so that it is possible to short out the current transformer under load. Suitable protective devices shall be provided to prevent high voltages in the event of open circuits.

All instrument and relay CTs shall be matched to optimize the metering scale and shall be ANSI Class 200, with 0.01% accuracy.

The synchronizing and loadshare control equipment shall be provided with their own PTs and CTs. CTs for loadshare control equipment shall be matched to optimize paralleling and load sharing functions. CTs shall be sized to provide stable load sharing from low to high load conditions. Transformers for voltage regulators shall not be used for any purpose other than voltage regulation.

Electronic components, such as those found in the PLC shall meet the requirements specified under ABS Rules for Building and Classing Steel Vessels, Part 4, Section 11 with respect to the suitability of equipment and environmental testing.

The switchboard shall include high quality process metering designed to provide the switchboard operator with accurate information. The metering systems should allow for ergonomic factors to facilitate the operator to simply and safely monitor, regulate and control the SSDGs and switchgear distribution power. All switchboard meters shall be Switchboard Class, transformer rated with 250° scale, accurate to ±1% of full scale with light emitting diode (LED) readout.

The switchgear shall provide protective relays for power protection of the SSDGs, Shore connection, SSB, Emergency Diesel Generator, Emergency Bus, and connected loads. Protective relays shall meet the requirements of ABS Steel Vessels, Part 4.

A system of automatic load shedding and/or power limiting shall be employed to prevent system black-out.

89.4 MAIN SWITCHBOARD

The switchboard(s) shall accommodate three (3) equally rated Ship's Service Diesel Generators (SSDG) arranged for parallel operation. The switchgear functionality is divided up by system. Each system will be constructed to provide independent instrumentation, and controls located in a relative switchboard cubicle. The system will be designed to parallel and load share any combination of SSDG to the Ship's Service Bus (SSB). With respect to Shore Power, the Shore Power system will be allowed to connect to the SSB in a closed transition or dead bus condition. The SSDGs can be paralleled under two (2) controlled configurations - either Manually or Automatically. In "Manual Mode" the generators operate with speed and voltage droop. The operator manually synchronizes and manually adjusts engine speed and generator voltage. In "Automatic Mode" the generators synchronize automatically and operate isochronously with constant voltage. The system shall be designed and constructed to operate each of the generators as stand alone units with the Ship's Service Bus or alternately where each generator set can be proportionally load shared between any combination of generator sets. Buses shall be designed to accommodate the maximum design service loads plus at least a 5-percent (≥5%) margin.

There shall be two (2) Ship's Service distribution sections located at opposite ends of the switchboard arranged so that each section supplies power for the equipment located on the corresponding end. The intent is to divide duplicate, vital loads on either side of the generator cubicles.

The Ships Service Switchboard shall be part of a line-up consisting of the following components arranged from left to right when viewed from the front:

1. Ship's Service Distribution Section (for End No. 1 equipment)
2. Generator No. 1 control and distribution section
3. Generator No. 2 control and distribution section
4. Generator No. 3 control and distribution section
5. Shore Power Section
6. Emergency Bus Tie Section

7. Ship's Service Distribution Section (for End No. 2 equipment)

The switchboard sections and the rest of the line-up shall be located on the EOS flat in a fore and aft direction. The sections shall be bolted together to form a single unit. Control and instrument wiring that extends between the sections shall be mated using terminal boards or pull-apart plugs. Bus sections shall be made up using bolted connections.

The Contractor shall provide wiring, connectors, nuts, bolts, hangers and other items and devices as required to make complete, functional, and fully operational electrical and mechanical interconnections between the switchboard sections and external components.

89.4.1 Switchboard Bus Construction

Through buses shall have adequate ampacity and shall be braced to have a short circuit current rating of 35 kA RMS symmetric, or greater. The switchboard buses shall be of sufficient cross sectional area to meet UL Standard 891.

The Ship's Service horizontal bus bars shall be mounted on glass polyester insulators with all three (3) phases arranged in the same vertical plane (edge–to-edge) braced and rated to withstand the maximum calculated short circuit conditions. The bus bars shall meet the requirements of 46CFR§111.30-19 and be sized in accordance with IEEE-45. Load bank taps, complete with silver plated copper lugs, shall be provided for the Ship's Service Bus that are accessible from the rear of the switchboard when the access panels are removed.

The bus shall be silver or tin-plated, hard drawn copper bar of sufficient size to limit the temperature rise to 65°C degrees over a 40ºC ambient degrees. All connections shall be torqued to manufacturers specifications using silver-plated, BELLEVILLE, or equal, washer/nyloc nut-bolt combination. All bus bar connections and joints shall be silver-plated (this includes connection surfaces on tin plated bus bars). All switchboard busing, including run backs, shall be bus bar. ***No flexible bus or cable shall be used***.

Buses to individual feeder circuit breakers shall be designed for the frame rating of the breakers and braced to the same rating of the main switchboard buses.

A-B-C type bus arrangement, top-to-bottom, left to right, and front-to-rear, as viewed from the front, shall be used throughout.

Construction shall allow maintenance and tightening of incoming line terminations, main device connections and all main bus bolted connections to be readily accessible.

89.4.2 Switchboard Outfitting Details

The switchboard shall incorporate switching and protective devices of the number, ratings and type noted herein with all necessary interconnections, instrumentation and control wiring. The switchboard shall be dead-front with all serviceable or replaceable components front accessible.

Except for Type "J" or "K" thermocouples and RTD's, the system analog input signals shall be 4-20 mA, two-wire, loop style for signal runs greater than twenty (>20) feet or where there is a close proximity to areas having high levels of parasitic energy (EMI or EMF) including galvanic or capacitive coupling between the signal cables and existing power cables or transmission cables in the wireways.

Potential Transformers (PT's) shall be used with instruments, meters, and relays. Control Power Transformers (CPT's) shall be used for control devices, where required.

NOTE: The EGCP-3 LS's shall be provided with dedicated potential and current transformers that shall not be used for any other control or monitoring functions. Fuses for line side potential transformers shall be rejection style cartridges sized for 35 kAIC. Transformers for voltage regulators shall not be used for any other purposes.

Load sharing and PID control equipment shall be provided with their own potential and current transformers. All instrument and relay current transformers shall be matched to optimize the metering scale and/or process and shall be ANSI Class 200, with 0.01-percent (0.01%) accuracy.

Relays that have sensitive characteristics and precision mechanisms or adjustments shall be housed in moisture and dust proof cases. Contactors, auxiliary relays, alarm relays and similar devices, which do not require such precision, shall be provided with suitable protective covers.

Insulating material shall have properties of high mechanical and dielectric strength and shall resist moisture absorption and deterioration from service temperatures. Insulating materials shall be of laminated phenolic, glass-polyester laminates, or equal. Porcelain or wood products **shall not** be used as insulating materials.

A one-line diagram shall be included on the front of the switchboard indicating the bussing scheme. The diagram shall be an engraved phenolic placard located during detailed design. A placard describing switchboard operation shall also be provided. The placard shall also provide instructions on the Maintenance Feedback operation and the manual override operation. The placards shall be approved by a WSF Representative prior to manufacture and installation.

For load shedding purposes, some of the distribution breakers shall be equipped with separately fused under voltage trips (UVR) powered from a separate, internal 24 Vdc bus in each section that shall be provided as part of the switchboard.

Control circuitry, the PLC, circuit breakers and equipment that requires external power shall be supplied from two (2) external sources of 24 Vdc. Isolation diodes inside each section of the switchgear shall be provided to obtain the "best available" source of supply. The isolation diodes shall be CRYDOM Part No. M50100SB1200, or equal, panel mounted, and rated for 100 Amps. The Contractor shall create a 24 Vdc control power bus within each section of the switchboard for control functions.

Surge voltage protection shall be provided for the 24 Vdc buses in the switchboard and the EOS Control Console. A coarse filter shall be provided for the primary sources to the DC bus. A finer filter shall be provided on the output of the "best available" source in each section and the console. Surge protectors shall be PHOENIX CONTACTS MCR – PLUGTRAB PT, or equal.

The Ship' Service Diesel Generators have anti-condensation heaters provided by the SSDG Contractor. The heaters are approximately 150 Watt and are powered from 120 Vac single-phase external source. The Contractor shall provide an interlocking circuit to energize the heater when the circuit breaker is open. An indicator light at the generator section shall indicate the heater is "ON". For maintenance purposes it shall be possible to disconnect and isolate each generator heater circuit without disabling other circuits.

89.4.3 Protection Devices

Circuit breakers shall meet UL Standard 489 or IEC 947-2 and shall be provided as 100-percent (100%) continuous current rated. Circuit breakers shall be calibrated for operation in a 40C degrees ambient space. Circuit breakers shall be provided with tin- or silver-plated copper lugs for making up line side and load side connections.

Molded case circuit breakers are to be totally front accessible. The circuit breakers are to be mounted in the switchboard to permit installation, maintenance and testing without reaching over any line side bussing.

The feeder or branch devices shall be removable from the front and shall be panel mounted with the necessary device line and load connections front accessible.

The protective features and interrupting ratings of circuit breakers shall be coordinated to provide protection for the electric plant without exposing the protected equipment to excessive thermal or mechanical stress, but in no case shall they have an interrupting

capacity less than 35 kA RMS symmetric. A coordination study shall be provided to demonstrate selectivity amongst all devices provided within this switchboard.

Spaces for future circuit breaker installation of at least 20-percent (≥20%) spares shall be provided. All spaces for future circuit breakers shall be equipped with the necessary connections/bases fully insulated and braced to accept the future breaker without the need for additional parts or mounting bases.

Breakers shall be equipped with accessories, including under voltage trip features, as required by the Authoritative Agencies and these Technical Specification.

89.4.4 Ship's Service Diesel Generator and Shore Power Protection

The Ship's Service Diesel Generator and Shore Power overcurrent protection shall be SQUARE D Masterpact® Type NW, or equal, draw-out circuit breakers with an 800 Amp frame, rated 600 Vac, stored energy devices with an Electronic Trip Unit 5.0P. The interrupting rating shall be 35 kA RMS symmetric at 480 Vac. The circuit breakers shall be rated for 100-percent (100%) continuous duty and calibrated for operation in a 40C degrees ambient environment. The Ampere rating shall be determined by the interchangeable rating plug in accordance with USCG requirements.

The generator circuit breaker adjustment settings shall be determined based on the generator rating, generator decrement curves, protective relay devices, the coordination study and other applicable engineering data.

The Shore Power circuit breaker adjustment settings shall be coordinated with the Vessel's Fire Pump motor starting curve to ensure that the pump can be started while on Shore Power with no "nuisance" trips.

After installation and adjustment, all of the SQUARE D Masterpact®, or equal, circuit breakers shall have affixed to the circuit breaker a permanent label plate listing all of the settings used in the coordination study. Additionally, the adjustment screws shall be painted after set-up. This information shall also be included on the One-Line Diagram. Tamper seals shall be attached after final adjustment.

The generator and shore power circuit breakers shall be mounted in the bottom of their respective sections.

The Micrologic® 5.0P Electronic Trip Units, SQUARE D, or equal, shall be capable of communicating serially with the switchboard PLC.

The Micrologic® 5.0P Electronic Trip Units, SQUARE D, or equal, shall be powered from the 24 Vdc bus in their respective sections.

One (1) hand-held SQUARE D Masterpact®, or equal, Test Kit, shall be provided for use on the Vessel.

A licensed version of SQUARE D Masterpact® System Management Software, or equal, including required cables for connecting a laptop to the Electronic Trip Unit, shall be provided for each Vessel.

The SQUARE D Masterpact® circuit breakers, or equal, shall have the following features unless noted otherwise:

Circuit Breaker

1. UL Type A rating plug (unless the coordination study dictates otherwise)
2. Circuit breaker communication module
3. Auxiliary contacts, minimum of eight (8); for breaker status lights in the circuit breaker switch and to hardwire the interlocks for PLC control failure so that manual control is available.
4. Spring charging motor, 24-30 Vdc (MCH)
5. Shunt trip, 24-30 Vdc (XF) utilized for reverse power trips
6. Mechanical operations counter (CDM)
7. Overcurrent trip switch (SDE)
8. “Padlock-able” pushbutton cover
9. Ready to close switch (PF)
10. Cradle rejection kit
11. Door escutcheon with transparent cover (CCP) P/N 685981
12. Undervoltage trip with adjustable time delay module (MN)
13. Electronic Trip Unit 5.0P with LSI, no ground fault, ammeter and power meter
14. M6C Programmable Contact Module

Cradle with backmold

1. Rear connected T-vertical terminations, top (RCTV)
2. Rear connected T-vertical terminations, bottom (RCTV)

Note: Terminations will require tin or silver plated, copper spreader bus plates be attached to take ship's cable.

3. Cradle position switch (CE, CD, CT)
4. Shutter and shutter lock
5. Spring charged interlock
6. Secondary wiring terminal shield
7. Features as required to mate to the circuit breaker described above.

The Contractor shall retain the services of the SQUARE D Company's, or equal, technical services division to perform isolation and dielectric strength tests as described in ANSI/IEEE C37 or UL 489 Standards on the SQUARE D Masterpact®, or equal, circuit breakers and associated solid state trip units after their shipment to the Contractor's facilities and prior to energizing the circuit breakers. A test report for each circuit breaker shall be submitted documenting the results. Test reports submitted by any other entity or testing organization will not be accepted.

The Ship's Service Diesel Generators and Shore Power sources shall have reverse power, phase loss, phase imbalance, phase sequence, undervoltage, and underfrequency protection in the circuit breaker. Reverse power protection in the circuit breakers shall be shadowed with a discrete reverse power relay for each source.

Reverse power protection shall be definite time trip, three-phase sensing, and shall trip the circuit breaker of the source in reverse power mode after five (5) seconds or on obtaining 10-percent (10%) reverse power, whichever comes first. This setting shall be confirmed during Dock/Sea Trials to ensure that there are no nuisance trips.

A synch-check relay, incorporating dead bus detection, shall be used for closing the generator or shore power circuit breakers in manual mode.

89.4.5 Emergency Switchboard Bus Tie Circuit Breaker

The Emergency Switchboard bus tie circuit breaker shall be a SQUARE D, Type NSJ circuit breaker, or equal with a solid-state trip unit. This breaker shall be allowed to only

close on a dead bus. Additionally, a lockout relay with indicator and switch shall be provided to prevent closure of this breaker.

89.4.6 Emergency Switchboard Maintenance Backfeed Circuit Breaker

The Maintenance Backfeed circuit breaker shall be provided with a "Kirk Key", or WSF approved equal, locking device that requires manual intervention on the Operator's part to complete the backfeed operation.

89.4.7 Ships Service Distribution Circuit Breakers

The Ship's Service distribution circuit breakers shall be SQUARE D Type Compact NS (plug-on) thermal-magnetic, molded case circuit breakers, or equal, calibrated for operation in a 40C degrees ambient environment.

The circuit breakers shall be arranged horizontally in two (2) vertical, opposing columns with the line side connections located in the center, or between the columns. NS style plug-in bases, or equal, shall consist of 150 Amp and 250 Amp frames. SQUARE D NSF circuit breakers, or equal, with auxiliary functions shall be provided with terminal blocks on the circuit breaker body and base and support arm so that the breaker can be removed without having to disconnect control wires.

The distribution arrangement shall arrange the frames in a symmetrical pattern from the top down with 10-percent (10%) spares, and at least one (1), of each frame/trip size to be installed.

All circuit breakers shall be configured as draw-out from a plug base. All circuit breakers shall be provided with line and load plug base assemblies. The line side plug base assembly connection shall be mounted with the top or line side connections oriented to the middle of the cubicle. The circuit breaker plug base line side bussing shall be braced to 35 kAIC and all bus-work shall consist of rigid copper bus-work with locking hardware. Trip units shall be capable of removal without requiring additional mounting hardware or tools.

The load side plug base assembly connection shall be mounted, braced and connected to stabs oriented and extending towards the rear of the cubicle for field cable connections which shall be accessible and made up from the rear. Connection stabs shall provide mounting for Contractor provided cable lugs to match load side connections. All connection stab bus-work shall be permanently stamped "A", "B" and "C" respective to phase near the connection lugs. Cable retention plates shall be provided to secure Vessel cable once it has entered the section from the top.

The design shall provide sheet metal removable front covers providing a cut out for the circuit breaker toggle, set point and trip mechanism. The cutouts shall provide a gasket to seal the covers around the cutout. Magnetic trip set points shall be delivered at their lowest setting commensurate with the coordination study. During commissioning, the Contractor shall confirm that set points preclude tripping of the protective devices. Set points shall be recorded in the Operating and Maintenance Manual.

Each circuit breaker shall be equipped with a padlock lockout bracket. The removable cover shall accommodate the padlock device. The distribution interior shall consist of a dead-front panel to which the plug base assemblies shall mount and extend thru pattern cut outs located on the dead-front. Provisions shall be made on the dead-front panel to provide terminal blocks located to make up all auxiliary circuit breaker connections.

Under voltage trip circuit breakers are required for circuits that interface with the Fire and Ventilation Systems Shutdown, Circuit FR. The circuit breakers feeding these power panels shall be interconnected to the appropriate shutdown circuits. Circuit breakers for ventilation fans shall be noted with “RED” phenolic with “WHITE” core plates on the switchboard and labeled "**IN CASE OF FIRE, TRIP TO STOP VENTILATION**". Undervoltage trips shall use 24 Vdc from an external power source, shall be separately fused and wired to a Customer use terminal board.

The Steering Gear motor feeder circuit breakers shall be of the instantaneous only trip type set in accordance with 46CFR §58.25-55(a)(2).

The Steering Gear circuit breakers shall be also equipped with auxiliary normally closed (NC) contacts and wired to the AMS. Auxiliary contacts shall be closed when the breaker is closed and shall open when the breaker is open or tripped.

Nameplates for coils on shunt trip and under voltage trip mechanisms shall show the voltage rating. Nameplates shall be “BLACK” engraved phenolic with “WHITE” core (lettering).

89.4.8 Synchronizing and Load Control

The Contractor shall integrate an ` supplied WOODWARD EGCP-3 LS controller, or equal, for each Ship’s Service Diesel Generator. The EGCP-3 LS’s shall be compatible with the Generator Contractor EFI (Electronic Fuel Injection) controllers. and shall have a speed bias output, open-delta 120 Vac PT inputs, and 24 Vdc power supply. The EGCP-3 LS’s shall be full function type. Model and firmware release number shall be approved by the WSF Representative.

The EGCP-3 LS’s shall be configured to load share with other EGCP-3 LS units connected to the load-sharing network.

The Contractor shall supply and integrate a WOODWARD EGCP-3 MC with matching PT's for Shore Power loading and unloading with the EGCP-3 LS controlled Ship's Service Diesel Generators. The EGCP-3 MC unit shall be wired and configured by the Contractor to synchronize any of the Ship's Service Diesel Generators to Shore Power by means of a closed transition transfer. The EGCP-3 MC shall be located in the Shore Power Section.

The Contractor shall provide each Vessel with a hand held tool for configuring, monitoring and calibrating the WOODWARD EGCP-3 LS and EGCP-3 MC units.

The EGCP-3 LS and EGCP-3 MC units shall be installed to meet WOODWARD factory acceptance practices. The Contractor shall follow WOODWARD guidelines for the use of twisted, shielded cables and ground terminations.

EGCP-3 LS and EGCP-3 MC parameters shall be set as close as possible to default or WOODWARD recommended values.

89.4.9 Voltage Regulation

Voltage control shall be accomplished with an analog connection between the EGCP-3 LS voltage bias output and the OFE BASLER DECS-100 AVR (Automatic Voltage Regulator) external reference voltage adjustment circuit.

A voltage raise/lower switch for adjusting the generator voltage in manual mode shall be installed at the switchboard for each generator.

Additionally an OFE BASLER MVC300 manual voltage regulator shall be installed for each Ship's Service Generator.

Both the automatic voltage regulator and the manual voltage control shall be mounted in the generator section of the switchboard. A 3-position rotary switch "Auto/Off/Manual", shall be utilized to select the source of voltage regulation.

89.4.10 Programmable Logic Controller (PLC) System

A PLC for load shedding, circuit breaker coordination and interlocks when backfeeding the Ship's Service bus with the Emergency Diesel Generator (EDG), as set forth in the *Backfeeding Of The Ship's Service Bus By The Emergency Diesel Generator* Subsection in this Section of the Technical Specification, and alarm and monitoring communications shall be installed in the Ship's Service Switchboard Emergency Bus Tie section. The PLC shall be a SIEMENS S7-300 PLC, or equal, consisting of a CPU 315-2DP configurable for a floating reference potential with removable jumper, a CP 343-1

Industrial Ethernet communications processor, a CP 341 communications module, and I/O modules of the S7 300 series.

The processor shall include a FEPROM with at least 2Mb of RAM.

Analog input module SM 331 shall be used to interface with the analog input signals.

Digital input module SM 321 shall be used to interface with the digital input signals.

Digital output module SM 322 shall be used to interface with output devices.

The WSF Representative shall determine which modules are suitable for each location. Commonality of components shall be an important factor in determining which I/O modules are used.

For the PLC I/O, 20-percent (20%) of the channels for each type of input or output shall be reserved as spares.

The PLC components shall be the manufacturer's latest revision and have the most current firmware.

The Contractor shall insure that the system shall be installed, connected and grounded as specified under SIEMENS S7 installation guidelines and practices.

Power for the PLC shall be derived from a redundant 24 Vdc bus.

The PLC shall communicate via Modbus RTU, or equal, communications to the Electronic Trip Units.

The PLC shall communicate via 100 Mbit/s Industrial Ethernet to the PSI Contractor's AMS Auxiliary PLC. The CP 343-1 module shall be connected through unshielded twisted pair cable and RJ-45 connectors to an optical switch module (OSM). The OSM shall be part of the AMS redundant ring Ethernet network.

89.5 INSTRUMENTATION

Meters and indicators shall be arranged logically using Sound Human Engineering so that they can be easily read and maintained. ASTM F1166 provides valuable human engineering information and, this or an equivalent standard, approved by the WSF Representative, shall be used as a guideline.

In general and where possible, switchboard instrumentation shall be arranged such that operator critical meters are not over 6'-8" above the finished deck and the height of the center of the selector switches, circuit breakers and push buttons are not over 6'-4" above the finished deck.

When determining the location and viewing angle for panel display, faces shall be perpendicular to the operator's line of sight (unless directed otherwise) and located in groups of logical or "expected" positions for rapid and easy identification of vital or critical readings.

Insulation resistance monitoring systems shall be mounted on the front of the switchboard distribution section to detect grounds in the distribution system. The switchboard shall include ground detection ammeters and test switches for each of the separately derived 480:208Y/120 Vac step-down transformers and indicating lights and test switches for the 480 Vac Ship's Service and Emergency buses.

The OFE automatic voltage regulators and the manual voltage regulators for the Ship's Service Diesel Generators shall be mounted in the respective generator sections on the switchboard.

OFE display panels for the Ship's Service Diesel Generators shall be mounted in the respective generator sections on the switchboard. An OFE display panel for the Emergency Diesel Generator shall be mounted in the Emergency Switchboard metering section of the Ship's Service Switchboard.

A diagnostic communication connection for connecting a laptop computer to the generator contractor's EFI controller shall be installed in each of the Ship's Service Diesel Generator sections and the Emergency Switchboard metering section. The connections shall be accessible from the front of the switchboard cubicles.

An additional diagnostic communication connection for the EGCP-3 LS shall also be installed in each Ship's Service Diesel Generator section. A diagnostic communication connection for the EGCP-3 MC shall be installed in the Shore Power section.

89.5.1 Switchboard Metering

Switchboard meters shall be CROMPTON 077-DI Series, LED Digital/Analog Combination meters, or equal. Unless otherwise indicated, the meters shall be sealed case, semi-flush, 4½-inch circular, switchboard style, transformer-rated, 250 degree scale, and accurate to ±1% of full scale. Instruments shall have jeweled pivots or taut band suspension as appropriate. The LED display shall be powered from a 24 Vdc supply.

The meters shall have "WHITE" dials with "BLACK" scale markings. Voltage, current, and kW meters shall have a "red-line" indicating rated values.

At least three (3) nuts shall be provided on each instrument stud for securing conductors to the instrument. All instrument studs shall have insulated boot tips to prevent operator contact with live electrical circuits when the control panel doors are open.

All switchboard-indicating instruments (except ammeters) shall be fused in accordance with 46CFR §111.30-17.

At the time of delivery, all switchboard meters shall have attached on their face a recent (within ten (10) days of delivery) calibration sticker showing date of calibration, expiration date, and the calibrating company and individual's name.

Switches installed for instrument transfer or control functions shall be of the rotary type. They shall be equipped with clearly marked escutcheon plates to indicate their positions and function and shall be provided with positive positioning devices to securely hold the switch in the selected position. For WSF Fleet-wide Standardization purposes, all instrumentation and control switches shall be manufactured by the ELECTRO SWITCH Corporation, Series 24, unless specified differently elsewhere in the Technical Specification. Grip or handle styles shall be approved by WSF.

The Ship's Service Diesel Generator metering sections shall include the following meters and meter switches:

1. Voltmeter - 600 Vac full scale.
   Voltmeter Phase Selector Switch - four (4) positions – "phase-to-phase" voltages and "OFF".

2. Ammeter – 800 Amp full scale.
   Ammeter Selector Switch - four (4) positions - phase currents and "OFF".

3. Frequency Meter – 55 to 65 Hz range, ±0.15 Hz accuracy. The meter shall read 55 Hz with no power applied.

4. Kilowatt Meter - 600 kW full scale, capable of reading 15-percent (15%) of reverse power.

5. kVAR Meter - 0 – 600 kVAR.

6. Synchroscope, CROMPTON 077 Series.

7. SSDG Engine Hour Meter (one (1) each engine), REDLION Model C48T digital LED Dual Preset, or equal.

The Shore Power metering sections shall include the following meters and meter switches:

1. Voltmeter - 600 Vac full scale.
   Voltmeter Phase Selector Switch - four (4) positions – "phase-to-phase" voltages and "OFF".

2. Ammeter - 250 Amp full scale.
   Ammeter Selector Switch - four (4) positions - phase currents and "OFF".

3. Frequency Meter - 55 to 65 Hz range, ±0.15 Hz accuracy. The meter shall read 55 Hz with no power applied.

4. Kilowatt Meter - 200 kW full scale, capable of reading 15-percent (15%) of reverse power.

5. Shore Power Phase Rotation Indicator – CROMPTON 077 Series, 4½" × 4½"-dial, with direction indicating arrows and three-phase power available indicator lights.

6. Synchroscope, CROMPTON 077 Series

Emergency switchboard metering section at the Ship's Service Switchboard shall include:

1. Voltmeter - 600 Vac full scale.
   Voltmeter Phase Selector Switch - four (4) positions – "phase-to-phase" voltages and "OFF".

2. Ammeter - 250 Amp full scale.
   Ammeter Selector Switch - four (4) positions - phase currents and "OFF".

3. Frequency Meter - 55 to 65 Hz range, ±0.15 Hz accuracy. The meter shall read 55 Hz with no power applied.

Ground detection meters shall be mounted near the top of the distribution section from which its power distribution feeder circuit is derived. Ground detection meters shall be provided for each transformer bank, Ship's Service Bus, and Emergency Bus. Due to the mounting height above the deck, these meters shall be tilted or angled down to allow for easy Operator viewing. The Contractor shall wire the meters to a Customer use terminal board for connection by others to the new, Contractor provided remote CT's. These meters shall be overcurrent protected, of the logarithmic type with expanded scale 0-10 Amp (up to 1000 Amp), CROMPTON, or WSF approved equal. Provide a CROMPTON 194-GF sensor for each meter. A test switch to monitor neutral ground current on the 208Y/120 Vac buses shall be provided. The test switch shall simultaneously short the

neutral ground current sensing CT and open the circuit to the meter using a make-before-break switching scheme. Other aspects of these meters shall be similar to those provided for the voltmeters and ammeters described above with the exception that digital readouts are not required. For the delta connected buses, provide three (3), clear ground detection lights and test switch.

Voltmeters for all 24 volt battery banks shall be provided in the Emergency Bus Tie section of the switchboard. Voltmeters shall be CROMPTON 077-DI Series, LED Digital/Analog Combination meters, or equal.

89.5.2 Indicator Lights and Switches

Pushbuttons shall be SQUARE D Type K, or equal.

Indicator lights shall be IDEC SLC40 Series panel mounted. indicator lights shall be flush mounted and shall be provided with a colored lens to convey the desired indication. The color shall be integral with the lens and not externally applied.

The Ship's Service Diesel Generator section shall include the following switches and indicator lights:

1. "Manual/Auto" mode switch – 2-position
2. Circuit Breaker Open/Trip/Close Switch – 3-position, spring return to center, with "close-trip-open" indicator lights
3. "Auto/Off/Manual" 3-positionVoltage Regulator select switch
4. Idle/Rated Speed switch – 2-position, with guard
5. Voltage "Raise/Lower" switch – 3-position, spring return to center
6. Speed "Raise/Lower" switch – 3-position, spring return to center
7. Synchronizer "On/Off" – 2-position Switch
8. Engine "Start" pushbutton – with guard
9. Engine "Stop" pushbutton – with guard
10. Emergency Stop switch
11. Emergency Stop light – "RED"
12. Pre-lube switch – 3-position, Auto/Off/Manual

13. Pre-lube Start illuminated pushbutton – "BLUE"
14. "Power Available" light – "WHITE"
15. "Generator Run" light – "GREEN"
16. "Generator Heater On" light – "GREEN"
17. Generator Over-speed light – "RED"
18. Generator Shutdown light – "RED"
19. Generator Reverse Power light – "RED"
20. Generator Ready to Start light – "GREEN"
21. Generator Controls in Auto light – "GREEN"
22. Generator Controls in Manual light – "AMBER"
23. SCAC (Separate Circuit After Cooler) Cooling Pump Run – "GREEN"
24. "Lamp Test" pushbutton

The Shore Power control and display section shall include the following switches and indicator lights:

1. "Manual/Auto" mode – 2-position
2. Circuit Breaker Open/Trip/Close Switch – 3-position, spring return to center, with "close-trip-open" indicators
3. Synchronizer "On/Off "– 2-position switch
4. Shore Power Reverse Power trip light – "RED"
5. Power Available light – "WHITE"
6. Lamp Test pushbutton

The Emergency Switchboard display section, located on the Ship's Service Switchboard, shall provide indication of conditions on the Emergency Bus, and shall indicate the source of power supply to that bus. It shall be provided with the following:

1. Emergency Generator Power Available light – "WHITE"
2. Emergency Generator Lockout pushbutton

3. Emergency Generator Supplying Power to the Emergency Bus (based on the status of ABT-2) light – "AMBER".
4. Emergency Generator in Auto light – "GREEN"
5. Emergency Generator in Manual light – "RED"
6. Emergency Bus Maintenance Backfeed Power Available light – "RED"
7. Ship's Service Switchboard Supplying Emergency Bus light – "GREEN"
8. Emergency Generator Backfeeding Ship Service Bus – "RED"
9. Emergency Generator in Test Mode light – "RED"
10. Emergency Generator Overcrank Alarm – "RED"
11. Emergency Generator Crank Timeout Alarm – "RED"

The Power Available lights shall illuminate only when the source is available for connecting to the bus.

89.6 FUNCTIONAL SPECIFICATION

The Ship's Service Switchboard shall have the following capabilities:

1. It shall be possible to manually and automatically parallel all three (3) Ships Service Diesel Generators in any combination. Normal practice will be to have two (2) generators paralleled.

2. It shall be possible to manually and automatically synchronize the Ship's Service Bus with Shore Power for a closed transition transfer from Ship's Power to Shore Power and from Shore Power to Ship's Power. It shall not be possible to export power to shore. The Vessel shall not be able to connect to a dead Shore Power Bus and the Shore Power connection shall open when the shore power bus goes dead.

3. It shall be possible for the Ship's Service Diesel Generators to feed the Ship's Service Bus and the Emergency Bus.

4. It shall be possible to manually and automatically close any Ship's Service Diesel Generator or Shore Power circuit breaker to a dead, isolated Ship's Service bus.

5. It shall be possible for the Emergency Bus to backfeed the Ship's Service Bus using the Maintenance Backfeed circuit breakers. It shall not be possible for the Emergency Generator to parallel with the Ship's Service Diesel Generators or Shore Power.

6. It shall be possible to operate with the Ship's Service Bus and the Emergency Bus separated (i.e., with the Emergency Bus Tie circuit breaker open).

Paralleling shall be possible by allowing any one (1) of the four (4) power sources for the Ship's Service Switchboard (three (3) Ship's Service Diesel Generators and one (1) Shore Power connection) to be paralleled with the Ship's Service Bus. Shore Power shall be paralleled only for the purposes of transferring the loads during a twenty (20) second transition period.

Although not the normal operating profile, it shall be possible to parallel all three (3) generators together.

In any combination or number, paralleled generators shall share the active load (kW) and reactive load (kVAR) equally, on a percentage basis, evenly divided between the units.

89.7 ENGINE CONTROL

Each Ship's Service Diesel Generator section shall have a start and a stop pushbutton switch for manually starting and shutting down the individual diesel engine.

Each Ship's Service Diesel Generator section shall have an Idle/Rated speed two-position switch for speed setting of the individual diesel.

Each Ship's Service Diesel Generator shall have a pre-lube mode switch for switching to "Automatic" pre-lube or "Manual" pre-lube mode. In "Automatic" pre-lube mode the generator controls shall automatically control the pre-lube pump at programmable timed intervals. In "Manual" pre-lube mode the Pre-lube Pump is started by pressing the "Pre-lube Start" pushbutton. The "Pre-lube" indicating light is "ON" when the Pre-lube Pump is running. A pressure switch in the generator lube oil system shall automatically stop the Pre-lube Pump when a predetermined pressure has been reached.

89.7.1 Modes of Operation

Each of the four (4) Ship's Service Bus power sources, a generator or Shore Power, shall operate in either "Automatic" or "Manual" mode. The mode is selected with an Auto/Manual two-position switch at the source section.

89.7.2 Automatic Mode

"Automatic" mode is the normal mode of operation.

In "Automatic" mode the diesel generators are pre-lubed and started by pushing the respective "Pre-lube" and "Start" pushbuttons. The engines are also stopped manually by pushing the "STOP" pushbuttons.

In "Automatic" mode the engines shall loadshare isochronously and voltage shall be regulated at a constant set-point.

In "Automatic" mode a source is connected to the bus by turning the Circuit Breaker Close switch to the "CLOSE" position at the selected source until a circuit breaker close light on the escutcheon plate indicates the breaker is "Closed". As long as power is available for the selected source, the source shall attempt to synchronize with the bus, and match voltage with the bus. If the bus is dead the circuit breaker shall close immediately. If the bus is already energized, the circuit breaker shall close when the source is synchronized with the bus. Incoming generator sources connecting to an energized bus shall ramp up from zero load to the point of proportional loadsharing.

In "Automatic" mode a source is disconnected from the bus by turning the circuit breaker "OPEN" switch to the open position at the selected source. A generator source disconnecting from the bus shall unload by ramping down to the minimum load set-point, at which point the circuit breaker opens.

For Ship's Service Diesel Generators in Automatic Mode, the EGCP-3 LS shall perform the functions of synchronization, circuit breaker control, isochronous speed control, active and reactive load control, and voltage regulation.

For Shore Power in Automatic Mode, the EGCP-3 MC shall perform the functions of synchronization, circuit breaker control, and active and reactive load control.

89.7.3 Manual Mode

In "Manual" mode the diesel generators are pre-lubed and started by pushing the respective "Pre-lube" and "Start" pushbuttons. The engines are also stopped manually by pushing the "Stop" pushbuttons.

"Manual" mode for a power source is selected using the "Auto/Manual" switch at the generator or Shore Power control section. The incoming source is then synchronized with the bus by adjusting the engine speed with the "Raise/Lower" switch, turning the synchronizer switch to the "ON" position, and observing the synchroscope at the

generator control section. When synchronized, a synch-check relay gives a permissive to close the circuit breaker. The circuit breaker is closed manually from the appropriate generator or Shore Power control section.

In "Manual" mode the Ship's Service Diesel Engines shall loadshare in speed droop mode. The kW loads may be adjusted using the speed raise/lower switch in the respective generator section of the switchboard.

In "Manual" mode the voltage regulation shall be independent of the EGCP-3 LS. The voltage regulators shall be in voltage droop mode and the voltage set-points for each generator set with a voltage "Raise/Lower" switch located in each Generator Section.

89.7.4 Load Transfer to and from Shore Power

The transfer from Ship's Power to Shore Power is initiated by turning the Shore Power circuit breaker switch to the close position. The source of power on the Ship's Service Bus shall be synchronized with Shore Power, and the Shore Power breaker closed. Load transfer to or from Shore Power shall not last longer than twenty (20) seconds. After this time the circuit breaker for the source originally supplying the bus shall be automatically opened.

The process of transferring from Shore Power to Ship's Power is initiated by turning the breaker switch for any of the incoming Ship's Service Diesel Generators to the close position. The generator shall be synchronized with Shore Power and the generator circuit breaker closed. The shore power circuit breaker shall than automatically open within a twenty (20) second period.

It shall also be possible to close the Shore Power breaker to a dead bus.

The Shore Power circuit breaker shall be blocked from closing if the load current exceeds the setting of the shore power overcurrent protection. This setting shall be visible on the shore power ammeter.

89.7.5 Load shedding

If the load on any one (1) generator exceeds 105-percent (>105%) of the rated power, some of the switchboard non-vital loads, such as Food Vending or HVAC load, shall be automatically shed so that the highest generator load falls to less than 95-percent (<95%) of rated power. Loads to be shed shall have a breaker operator which when activated shall open the selected circuit breaker. Loads shall be shed in a sequential order according to a priority scheme. Loads shall be added back on manually in a sequence determined by the operator.

89.7.6 Backfeeding of the Ship's Service Bus by the Emergency Diesel Generator

Backfeeding of the Ship's Service Bus shall be possible only under operator initiated actions via the Maintenance Backfeed Circuit Breakers. If the load on the Ship's Service Bus exceeds 95-percent (>95%) of the Emergency Diesel Generator's (EDG) rating, the Maintenance Backfeed Circuit Breaker shall open automatically.

The Maintenance Backfeed Circuit Breaker on the Emergency Bus shall be interlocked so that it can be closed only after the EDG is producing power. The Maintenance Backfeed Circuit Breaker on the Ship's Service Bus shall be interlocked with the three (3) Ship's Service Generator circuit breakers, the Shore Power Circuit Breaker, and the Normal Emergency Bus Tie Circuit Breaker, such that if any of these breakers are closed or attempt to close, the Maintenance Backfeed Circuit Breaker shall open. It shall not be possible to parallel the Emergency Diesel Generator with the Ship's Service Generator.

The three (3) main required steps which guard against accidental cross connects are:

1. The EDG must be producing power.

2. The Maintenance Backfeed Circuit Breaker on the Emergency Bus must be manually closed after the EDG is running. A "Power Available" light on the Ship's Service Switchboard indicates that the circuit breaker is "Closed" and providing backfeed power to the Maintenance Backfeed Circuit Breaker on the Ship's Service Bus.

3. The Ship's Service Backfeed Circuit Breaker shall only be closed after all Ship's Service Diesel Generator, Shore Power, and Normal Emergency Switchboard bus-tie breakers are open, and the "Kirk Key" lock has been opened.

As this step is a three (3) step manual operation, it must be a conscious effort to accomplish powering the Ship's Service Switchboard from the EDG and Switchboard.

89.8 EMERGENCY SWITCHBOARD

The Emergency Switchboard shall be arranged for control of the Emergency Diesel Generator, including automatic transfer equipment, and for the distribution of emergency power.

The Emergency Switchgear is to be located as close as practical to the EDG.

The Emergency Switchboard is to provide for control, operation, and protection of the EDG and Emergency distribution system.

Previously mentioned Technical Specification mechanical and electrical requirements shall apply to the Emergency Switchboard design construction where applicable.

The Emergency Switchboard shall be equipped to maintain power to vital shipboard functions required to sustain the Vessel. These functions include control, communication, detection, interior communications and lighting.

Under normal operations the Emergency Switchboard loads shall be provided with ship's power from the Ship's Service Bus via an Automatic Bus Transfer (ABT) system.

The Emergency Diesel Generator control system shall be designed and provisioned with an automatic generator starting system including starting batteries. The batteries shall be capable of providing six (6) consecutive starts. The battery is to be protected from depletion by the Automatic Starting System. See Section 96 of the Technical Specifications for additional battery requirements.

The Emergency Switchboard shall be equipped to provide an alternate power source to the Main Switchboard for damage control with the intent being limited to Emergency Power for starting any one (1) auxiliary power system.

The Emergency Diesel Generator system shall be integrated with an PSI Contractor (OFE) supplied WOODWARD EGCP-3 LS controller for "auto start" functions, ABT transfer control, and interfacing to the Vessel's Alarm and Monitoring System. The EGCP-3 LS shall communicate via PROFIBUS, Modbus RTU, or equal, communications to the generator circuit breaker Electronic Trip Unit.

The Emergency Switchboard shall be part of a line-up consisting of the following components arranged from "left-to-right" when viewed from the front:

1. EDG Control Section
2. Emergency Bus ABT/Distribution Section #1
3. Emergency Bus Distribution Section #2

Previously mentioned switchboard bus construction, outfitting details, protection devices, emergency bus distribution circuit breakers, and generator circuit breaker requirements shall also apply to the Emergency Switchboard design, except that synchronizing, kW load share, and kVAR load share shall not be required.

89.8.1 Automatic Bus Transfer (ABT)

Under normal operation the Emergency Switchboard shall be provided with power from the Ship's Service Switchboard through an Automatic Bus Transfer (ABT) system. The ABT shall consist of two (2) circuit breakers, a Ship's Service Switchboard Tie and the Emergency Diesel Generator circuit breaker, both of which shall be SQUARE D Masterpact® NW, or equal, circuit breakers.

The Emergency Switchboard PSI Contractor (OFE) supplied WOODWARD EGCP-3 LS controller shall monitor and control the switching sequence of the ABT. The ABT control logic shall monitor the voltage on the Ship' Service side of the bus tie circuit breaker, and initiate an Emergency Diesel Generator starting cycle when this voltage drops to 80-percent (80%) of the normal Ship's Service Bus voltage. The ABT control logic shall be set to open the bus-tie circuit breaker and close the Emergency Diesel Generator circuit breaker when the EDG attains 90-percent (90%) of its rated voltage.

After restoration of rated voltage on the Ship's Service Bus, the ABT will transfer power for the Emergency Switchboard from the Emergency Diesel Generator back to the Ship's Service Bus. The EDG shall continue to run for a five (5) minute "cool down" period, at which point the ABT control will signal the EDG to shutdown, with the EDG prepared to re-start should it be required to resume operation.

The ABT control logic shall be supplied with a momentary test push-button switch to simulate the loss of Ship's Service Switchboard power and initiate the engine starting and bus transfer cycle. A "RED" indicating light on the Emergency Switchboard and in the Emergency Section of the Ship's Service Switchboard shall illuminate when the ABT system is in the test mode.

89.8.2 Emergency Service Distribution Circuit Breakers

The Ship's Service distribution circuit breakers shall be SQUARE D Type Compact NS (plug-on) thermal-magnetic, molded case circuit breakers, or equal, calibrated for operation in a 40C degrees ambient environment, with same features as explained in the Ship's Service Distribution Circuit Breaker section of this Technical Specification.

89.8.3 Voltage Regulation

Voltage control shall be accomplished with an (OFE) provided BASLER DECS-100 AVR (Automatic Voltage Regulator) and a Voltage Raise/Lower switch.

Additionally a BASLER MVC300 manual voltage regulator shall be provided with a voltage control cut-out switch and a potentiometer for controlling the exciter field directly.

Both the automatic voltage regulator and the manual voltage control shall be mounted in the EDG section of the switchboard. A 3-position rotary switch "Auto/Off/Manual", shall be utilized to select the source of voltage regulation.

89.8.4 Emergency Switchboard Metering

Switchboard meters shall be CROMPTON 077-DI Series, LED Digital/Analog Combination meters, or equal. Unless otherwise indicated, the meters shall be sealed case, semi-flush, 4½-inch circular, switchboard style, transformer-rated, 250 degree scale, and accurate to ±1% of full scale. Instruments shall have jeweled pivots or taut band suspension as appropriate. The LED display shall be powered from a 24 Vdc supply.

The meters shall have "WHITE" dials with "BLACK" scale markings. Voltage, current, and kW meters shall have a red line indicating rated values.

At least three (3) nuts shall be provided on each instrument stud for securing conductors to the instrument. All instrument studs shall have insulated boot tips to prevent operator contact with live electrical circuits when the control panel doors are open.

All switchboard-indicating instruments (except ammeters) shall be fused in accordance with 46CFR §111.30-17.

At the time of Vessel delivery, all switchboard meters shall have attached on their face a recent (within 10 days of delivery) calibration sticker showing date of calibration, expiration date, and the calibrating company and individual's name.

Switches installed for instrument transfer or control functions shall be of the rotary type. They shall be equipped with clearly marked escutcheon plates to indicate their positions and function and shall be provided with positive positioning devices to securely hold the switch in the selected position. For WSF Fleet-wide Standardization purposes, all instrumentation and control switches shall be manufactured by the ELECTRO SWITCH CORPORATION, Series 24, unless specified differently elsewhere in these specifications. Grip or handle styles shall be approved by the WSF Representative.

The Emergency Generator metering section shall include the following meters and meter switches:

1. Voltmeter - 600 Vac full scale.
   Voltmeter Phase Selector Switch - 4-position – "phase-to-phase" voltages and "OFF".

2. Ammeter – 800 Amp full scale.
   Ammeter Selector Switch - 4-position - phase currents and "OFF".

3. Frequency Meter – 55 to 65 Hz range, ±0.15 Hz accuracy. The meter shall read 55 Hz with no power applied. Two (2) position selector switch for reading "Bus" or "Generator" frequency.

4. Kilowatt Meter - 600 kW full scale, capable of reading 15-percent (15%) of reverse power.

5. Emergency Diesel Generator Hour Meter, REDLION C48T digital LED Dual Preset, or equal.

89.8.5 Emergency Indicator Lights and switches

Pushbuttons shall be SQUARE D Type K, or equal.

Indicator lights shall be IDEC SLC40 Series panel mounted. Indicator lights shall be flush mounted and shall be provided with a colored lens to convey the desired indication. The color shall be integral with the lens and not externally applied.

The Emergency Generator section shall include the following switches and indicator lights:

1. Circuit Breaker "Open/Trip/Close" switch – 3-position, spring return to center, with "close-trip-open" indicators

2. Voltage "Raise/Lower" switch – 3-position, spring return to center

3. Speed "Raise/Lower" switch – 3-position, spring return to center

4. "Auto/Manual" switch – 2-position, maintained contact

5. "Lamp Test" pushbutton - momentary

6. Emergency Generator Power Available light – "WHITE"

7. Emergency Generator Supplying Emergency Switchboard light – "AMBER"

8. Ship's Service Bus Power Available light – "WHITE"
9. Ship's Service Switchboard Supplying Power light – "GREEN"
10. Generator "Heater On" light – "GREEN"
11. Emergency Generator Backfeeding Ship's Service Bus – "RED"
12. Emergency Generator in Test Mode light – "RED"
13. Emergency Generator Overcrank alarm – "RED"
14. Emergency Generator Crank Timeout alarm – "RED"
15. Emergency Generator in Auto – "GREEN"

89.8.6 Auto Start EGCP-3 LS

The Contractor shall integrate an OFE supplied WOODWARD EGCP-3 LS controller, or equal, for automatic starting of the Emergency Diesel Generator in the event of failure of the normal Ship's Service supply. The EGCP-3 LS shall be installed in the Emergency Switchboard, and shall handle the automatic starting of the engine, the coordination of the circuit breakers involved in the transfer of the ABT for powering the Emergency Bus, automatic cool down, and shutdown functions as described in the *EMERGENCY FUNCTIONAL SPECIFICATION* Subsection in this Section of the Technical Specification.

A diagnostic communication connection for connecting a laptop computer shall be installed in the Emergency Switchboard Generator section.

The EGCP-3 LS unit shall be installed to meet WOODWARD factory acceptance practices. The Contractor shall follow WOODWARD guidelines for the use of twisted, shielded cables and ground terminations.

EGCP-3 LS parameters shall be set as close as possible to default or WOODWARD recommended values.

Power for the EGCP-3 LS shall be derived from redundant Propulsion Control 24 Vdc battery supplies.

89.9 EMERGENCY FUNCTIONAL SPECIFICATION

A 3-position switch (Auto/Off/Manual) shall be provide for starting the Emergency Diesel Generator. When in the "AUTO" position, the generator shall start automatically upon loss of voltage through the ABT. When power from the Ship's Service Bus drops to 80-percent (80%) of rated voltage, the ABT will signal the Emergency Diesel Generator (EDG) to automatically start. When the EDG reaches 90-percent (90%) of rated output voltage, the ABT will transfer power to the Emergency Switchboard from the Ship's Service Bus to the Emergency Diesel Generator.

After restoration of rated voltage on the Ship's Service Bus, the ABT will transfer power for the Emergency Switchboard from the Emergency Diesel Generator back to the Ship's Service Bus. The Emergency Diesel Generator shall continue to run for a five (5) minute cool down period, at which point the ABT control will signal the EDG to shutdown, with the EDG prepared to re-start should it be required to resume operation.

The automatic starting circuit shall be designed so that when there is a demand for the Emergency Diesel Generator, the starter shall turn over the engine for a ten (10) second period (this time period shall be adjustable), followed by a twenty (20) second rest period (also adjustable). A speed switch shall be utilized to detect when the engine has started so that power to the starting motor can be interrupted, and the "starting cycle" ended. If the engine does not start during the first ten (10) second cranking period, there shall be a twenty (20) second rest period followed by another ten (10) second cranking period. If the engine does not start after three (3) cranking periods an "Overcrank" alarm shall be generated. After three (3) additional cranking cycles a "Crank Timeout" alarm shall be generated and the automatic cranking cycle shall cease.

The "Off" Mode of operation shall shutdown the Emergency Diesel Generator if it was running in the "Auto" Mode. The ABT shall transfer back to the Ship's Service supply before the generator is secured. The "Off" Mode shall prevent the EDG from starting under any circumstances. The local "Start" pushbutton shall be inactive in this mode.

The "Manual" position shall bypass the Automatic Mode and allow the Emergency Diesel Generator to be started under any conditions. The engine shall be started by depressing the "Start" pushbutton on a (OFE) provided Local Control Panel. The engine shall be shut down by depressing a stop pushbutton on a (OFE) Local Control Panel.

89.10 SPARE PARTS AND INSTRUCTION MANUALS

Provide a list of recommended spare parts and special tools for those items which are Contractor furnished, together with parts lists and instruction manuals necessary to maintain

and service provided equipment and accessories in accordance with the requirements of Sections 86 and 100 of the Technical Specifications.

Instruction manuals shall comply with the following:

A. Forty-five (45) days prior to delivery of the equipment, furnish to WSF two (2) complete sets of Operating and Maintenance manuals for review.

B. WSF shall review the manuals and return one (1) copy with comments within fifteen (15) days of receipt. The Contractor shall incorporate the comments and provide six (6) final copies to WSF at least fifteen (15) days prior to delivery of the equipment.

C. In addition to the six (6) manuals provided above, one (1) copy of the Operating and Maintenance manual shall be shipped with the equipment.

D. Manuals shall be submitted as complete sets and shall be neatly bound under a single cover and properly indexed. Manuals shall include information on all equipment furnished, spare parts data listing, source and current prices of replacement parts and supplies, and recommended maintenance intervals and procedures.

E. The manuals shall include a functional description of the switchboard, bill of material, list of recommended spare parts and special tools, including current prices, for Contractor furnished items, software printouts including documented source code and parameter lists, OEM documentation including complete manufacturer's manuals and data sheets, submittal data and certified test reports on each component (e.g. secondary injection testing), and maintenance and troubleshooting procedures. The maintenance procedures shall include the overall assembly, operation, maintenance and installation instructions, renewal parts data, complete repair instructions, fabrication drawings, factory test reports, and drawings and specifications for all special tools provided. Intervals for cleaning and direction on which parts need cleaning and inspection for wear shall be included.

F. Provide six (6) sets of "D"-size certified, As-Built drawings. The complete drawing set shall be supplied in AutoCAD®, Release 2005 on CD-ROM or DVD-ROM.

G. Provide a written safety procedure for operating, maintaining and repairing the equipment.

89.10.1 Software

Documented source code and complete parameter lists shall be provided for all programmable devices supplied by the Contractor.

The Contractor shall supply any programming tools or software, including licenses, required to communicate with or program Contractor-supplied components.

89.11 TESTS, TRIALS, AND INSPECTIONS

Tests and/or trials shall be in accordance with this Section and Section 101 of the Technical Specification.

Inspections shall be performed as defined in this Section and in Sections 1 and 2 of the Technical Specification.

89.11.1 Factory Tests and Inspections

The switchboard, as a complete unit, shall be given a single short circuit type rating by the manufacturer. The rating shall be based on UL specifications. The switchboard shall be labeled to indicate the maximum available fault current rating and will be UL listed. A test program shall be developed and presented to the WSF Representative for review and approval prior to beginning the testing.

The switchboard shall be completely assembled, wired, adjusted and functionally tested to include all generator and shore power synchronizing and high potential testing at the manufacturer's facility. After assembly and before delivery to the Shipyard, the complete switchboard will be tested, in the presence of the WSF Representative, for operation under simulated service conditions to assure the accuracy of the wiring and the functioning of all equipment including meters. The test results and documents shall be provided to WSF for review.

The switchgear shall be tested in accordance with ANSI C37.20, Section 5.3, Standard Production Tests. These tests shall include:

1. Dielectric Tests
2. Mechanically Operation Test
3. Grounding of Instrument Transformer Case Test
4. Electrical Operation and Control Wiring Test

Functionality shall be tested by three-phase primary voltage and current injection. Individual generator control sections shall be synchronized with the Shore Power section using the Local Utility. Synchronizing features shall be demonstrated by using a variable frequency source at the primary voltage. A Load Bank shall be provided to load test each section.

Test memos shall be developed as set forth in this Section and Section 101 of the Technical Specification and submitted to the WSF Representative for review and approval not less than thirty (30) days prior to the beginning of the test. Review comments shall be incorporated into the approved document that shall be used for the actual conduct of the tests. Test memos shall demonstrate, as a minimum, the following:

1. AMS integration with switchboard instrumentation and alarms.

2. Set up of EGCP-3 LS's – Provide all set-points in a Microsoft® Excel™ spreadsheet format for review prior to testing. Demonstrate and document individual generator control stability with no load and as much load as can be applied while closed to the bus.

3. Demonstrate sync check mode by alternately closing generators to the bus then running alternate incoming generators with EGCP-3 LS's set to synchronizing check mode.

4. Demonstrate and document load sharing in “Manual” mode with two (2) generators (alternate) from low load to as much load as can be applied.

5. Demonstrate and document load sharing in “Manual” mode for three (3) generators with as much load as can be applied.

6. Demonstrate and document “Auto” mode of each generator to a dead bus.

7. Demonstrate and document “Auto” mode between running units and an incoming unit (alternate) for all three (3) generators.

8. Demonstrate and document shore power relays.

9. Demonstrate and document Shore Power circuit breaker settings and calibration.

10. Demonstrate and document EGCP-3 MC calibration and set-points by static testing.

11. Demonstrate and document base load – load/unload functionality between all generators and shore power. Check load set point functionality.

12. Demonstrate and document Test MCC logic.

13. Demonstrate and document Test Circuit FR logic.

89.11.2 Shipboard Tests, Trials, and Inspections

Start up, commissioning, and trials shall be included in the Contractor's scope of supply.

Functional testing shall be required on the Vessel after installation when all circuits are made up and equipment is installed and integrated into the line-up.

Thermal imagining of the completed installation of the switchboard in the Vessel shall be accomplished by the Contractor during Dock Trials to ensure that all connections are properly made.

The Contractor shall be responsible for demonstrating the FMEA, PSTP and Design Verification to the USCG.

89.11.3 Training

The Contractor shall provide five (5) days of on-site classroom training for four (4) groups of ten (10) individuals for the first Vessel, and two (2) groups of ten (10) individuals for the remaining Vessels. See the *TRAINING OF WSF PERSONNEL* Subsection in Section 1 of the Technical Specification.

At the WSF Representative's option, this training may take place all or in part after delivery of the Vessel, but before it is put into WSF Fleet service.

The training shall include the theory, installation, programming, operation, and maintenance of the following equipment:

1. SQUARE D Masterpact® NW circuit breakers, including Micrologic 5.0P trip unit
2. WOODWARD EGCP-3 LS and EGCP-3 MC controllers
3. BASLER DECS 100 voltage regulator

89.12 PHASE II TECHNICAL PROPOSAL REQUIREMENTS

The following deliverable, in addition to others required by Section 100 of the Technical Specification and the Authoritative Agencies, shall be provided during the Phase II Technical Proposal stage of Work in accordance with the requirements of Section 100 of the Technical Specification:

A. Electrical Power Systems Report

The ***Electrical Power Systems Report*** shall fully describe the installed systems used to manage and control the generation and distribution of electrical power on the Vessel. It shall address the following topics:

1. Sequence for automatic starting of a diesel generator
2. Control of diesel generator circuit breakers
3. Interface with programmable controllers
4. Alarm monitoring and display of the status of the electrical system
5. Protection device interface
6. Loads to be considered for load shedding and hierarchy of shedding these loads
7. Parallel operations when using Ship's Service Diesel Generators

See Section 100 of the Technical Specification for additional requirements regarding technical documentation.

89.13 PHASE III DETAIL DESIGN AND CONSTRUCTION REQUIREMENTS

The following deliverables, in addition to other deliverables required by Section 100 of the Technical Specification and the Authoritative Agencies, shall be provided during the Phase III Detailed Design stage of Work in accordance with the requirements of Section 100 of the Technical Specification:

A. Failure Modes and Effects Analysis (FMEA)

B. Periodic Safety Test Procedure (PSTP)

C. Design Verification

A block diagram shall be provided, suitable for mounting near the switchboard, illustrating the interconnection of the switchboard buses, transfer switches, tie switch, principal circuit breakers and controls that will guide an operator in emergency (local) procedures.

See Section 100 of the Technical Specification for additional requirements regarding technical documentation.

Provide six (6) complete sets of the detailed switchboard arrangement drawings to WSF for review and approval before constructing the switchboard.

Final Contractor drawings shall be furnished as "As Built", providing the following information: switchboard voltage/current rating, fault current rating/bracing, overall outline dimensions including available cable entry space; switching and protective device frame and thermal trip ampere ratings; one line diagram; detailed wiring diagram (including point-to-point wiring diagrams, "node" type of drawings **do not** meet this requirement); switchboard front panel arrangements; heat load released to the space; bus bar torquing requirements and switchboard dimensions and weights. A complete material list for all components within the switchboard shall be provided. Drawings are to be provided in electronic format compatible with AutoCAD®, Release 2005. See the *Modes of Operation* Subsection in this Section of the Technical Specification for additional details.

The Contractor shall prepare a ***Failure Modes and Effects Analysis (FMEA), Periodic Safety Test Procedure (PSTP)*** and ***Design Verification*** for the Contractor provided switchboard and its controls in accordance with 46 CFR Subchapter I, §61 and §62. The documents shall be submitted to the USCG for review and approval. The approved documents shall be bound in a document suitable for retention on board for use during annual inspections. The documents shall be written in a manner such that the demonstration is carried out in a sequential, step-by-step manner that minimizes the amount of time and effort required to conduct the procedure. This goal shall be taken into account in the design, construction and products used within the equipment.

(END OF SECTION)